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Wide-area Disaster Prevention of Storm or Flood Damage and Its Improvement by Using Urban Planning Information System

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Abstract

Recently, due to abnormal weather such as heavy rain in the local area, some unanticipated disasters have occurred in many areas of Japan. While resourceful disaster prevention measures are being required to this situation, General disaster prevention measures included not only “Public-assistance” but also “Mutual-assistance” and “Self-assistance” have been promoted in Japanese local government. Getting information related weather change quickly and accurately is demanded to carry out “Self-assistance”.

In this study, we carried out research based on the viewpoints of residents.

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Keywords: Disaster Prevention, Shelter, GIS, Wide area map for Disaster Prevention, Storm or Flood Damage

1. Introduction

1-1. Background and Study Purpose

Japan is located in the Circum-Pacific Mobile Belt where seismic and volcanic activities occur constantly. Although the country covers only 0.25% of the land area on the planet, the number of earthquakes and active volcanoes is quite high. Also, because of geographical, topographical and meteorological conditions, the country is

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subject to frequent natural disasters such as typhoons, torrential rains and heavy snowfalls, as well as earthquakes and tsunami. [1]

The disaster prevention measures have been carried out mainly on hard infrastructures in Japan. These hard infrastructures were planned by damage assumption plan based on damage scale of disaster in the previous disaster.

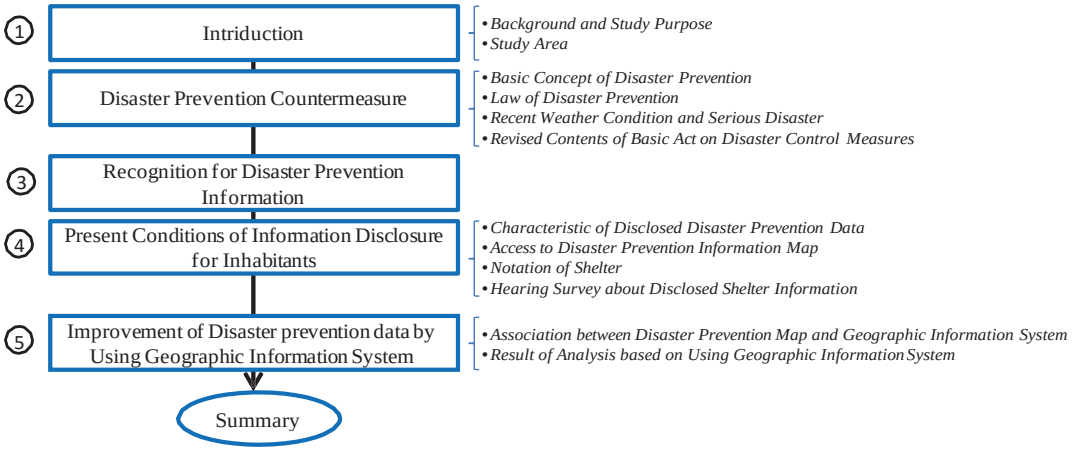

Fig 1. Study Flow

Recently, due to abnormal weather such as heavy rain in local area, some unanticipated disasters have occurred in many areas of Japan. While flexible disaster prevention measures is being required against these situations, Japanese local governments have promoted some disaster prevention measures included not only “Public-assistance” but also “Mutual-assistance” and “Self-assistance”. Now, national or local government announced disaster prevention hazard maps that included evacuation place, disaster prediction points and knowledge for disaster to provide the residents the information about disaster at hand in their daily life. In this way, the people can “self-assist” themselves to prevent from disaster based on the knowledge of hazard map in the case of disaster.

In this paper, we carried out research on wide-area disaster prevention information from the viewpoints of residents (Fig 1). First, we investigate the situation of wide-area disaster prevention information of storm or flood damage and then try to verify how that information contributes to the prevention activity of citizen for disaster. Finally, we try to propose a scheme to construct a database of disaster prevention information for the wide-area or specific area based on urban planning information system.

1-2. Study Area

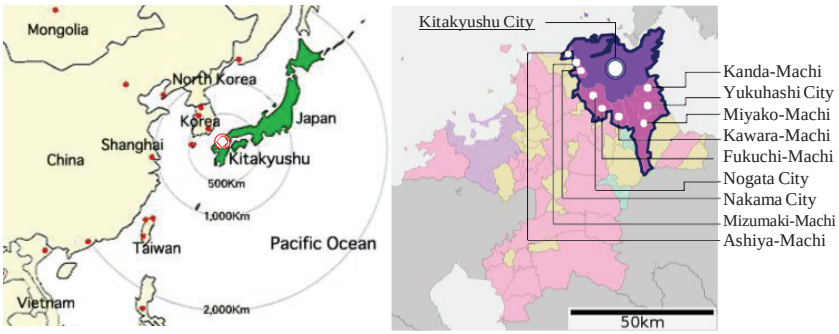

Fig 2. (L) Place of Kitakyushu City, (R) Study Area [2)]

In this study, we focused on “Storm or Flood Damage”. As shown in fig 2, the range of study area includes Ashiya, Mizumaki, Nakama, Nogata, Fukuchi, Kawara, Miyako, Yukuhashi and Kanda around Kitakyushu,

Fukuoka and Kumamoto. These areas have the same river basin, Onga River, which is one of “the first-class rivers” designated and managed by the national government.

2. Disaster Prevention Countermeasure

In this session, we illustrate the basic concept of disaster prevention in Japan and thinking the transition to the recent years of disaster prevention. (Fig 3)

2-1. Basic Concept of Disaster Prevention

It is a national priority to protect national land as well as citizens’ lives, livelihoods, and property from natural disasters. The turning point for strengthening the disaster management system came into effect in response to the immense damage caused by the Typhoon Ise-wan in 1959. In 1961, the enactment of the Disaster Countermeasures Basic Act was carried out due to formulate a comprehensive and strategic disaster management system. After that, the disaster management system has been continuously reviewed and revised following the lessons learned from large-scale disasters.

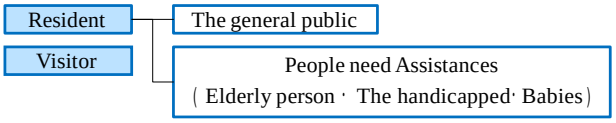

Fig 3. Concept of Refugee[3)]

2-2. Law of Disaster Prevention

Japan’s legislation for disaster management system, including the Disaster Countermeasures Basic Act, addresses all of the disaster phases of prevention, mitigation and preparedness. Roles and responsibilities between the national and local governments defined clearly about emergency response as well as recovery and reconstruction. Also, it is stipulated that public organizations cooperate with private organizations each other due to implement various disaster countermeasures.

The Disaster Countermeasures Basic Act has been reviewed and amended constantly since its first enactment. Especially, with lessons learned from the Great East Japan Earthquake, provisions were added three matters.

Firstly, the measures concerning support activities mutually done by local governments were enhanced in 2012. Secondly, the measures for ensuring smooth and safe evacuation of residents and improving protection of affected people were enhanced in 2013. In 2014, provisions were added for strengthening measures against unattended cars in order to promptly clear them from the roads for emergency vehicles.

2-3 Summary of Flood Control Act

In order to reduce damage caused by severe weather disasters, structural measures such as improving rivers, dams and sewage systems, and non-structural measures such as preparing hazard maps and providing disaster management information must be promoted in an integral manner. As non-structural countermeasures, the warning and evacuation systems for the possible inundation areas and landslide prone areas have been developed by the Flood Control Act and the Sediment Disaster Prevention Act. Based on the Flood Control Act, 417 rivers subject to flood warning and1,555 rivers subject to water-level notifications are designated. Of these, inundation risk areas are currently designated and published for 1,931 rivers (as of March 2014). Moreover, municipalities that include such areas are encouraged to prepare and disseminate flood hazard maps. Currently, 1,272 municipalities have published such maps (as of March 2014). [1]

“Flood Control Act” is one of "Basic Act on Disaster Control Measures". This law specializes in emergency for Flood Disaster such as “Storm or Flood Damage” (Flood, Tidal Wave) and “Tsunami”. “Flood Prone Area” in “Flood Control Act” is related to “Designated Emergency Evacuation Place and Designated Shelter” that are listed in "Basic Act on Disaster Control Measures".

2-4. Recent Weather Condition and Serious Disaster

In late years, the outbreak number of times of localized downpour such as the number of times more than precipitation 50mm per one hour is increasing (Fig 4). Also, “Serious Disaster” such as heavy disaster by “Earthquake” and “Storm or Flood Damage” is occurring many times.

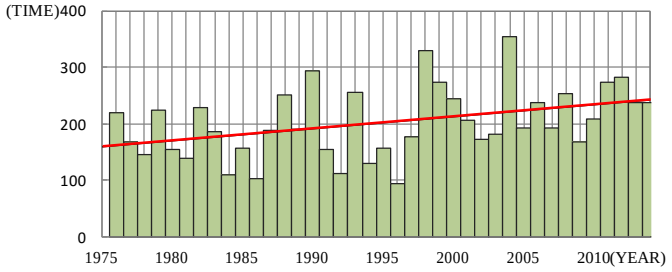

Fig 4. Times of 50mm/hr [4)]

2-5. Revised Contents of Basic Act on Disaster Control Measures

The Basic Disaster Management Plan is a comprehensive and long-term disaster management plan forming a foundation for the Disaster Management Operations Plan and Local Disaster Management Plan. It stipulates provisions for the establishment of the disaster management system, promotion of disaster management measures, acceleration of post-disaster recovery and reconstruction measures, and promotion of scientific and technological research on disaster management.

The plan was revised entirely in 1995 based on the experiences of the Great Hanshin-Awaji Earthquake. It defines responsibilities of each entity such as the national and local governments, public corporations and other entities. It consists of various plans for each type of disaster where specific countermeasures to be taken by each entity are described according to the disaster management phases of prevention and preparedness, emergency response, as well as recovery and reconstruction. Further, based on the lessons learned from the Great East Japan Earthquake, a new chapter was created in December 2011. For Tsunami Disaster Countermeasures and changes were made in September 2012 and January 2014, they were reflecting amendment of the Disaster Countermeasures Basic Act and the study results by the Nuclear Regulatory Authority (NRA) respectively. On November 2014, another alteration was made to reinforce the measures for removing unattended cars in case of emergency. A further alteration was made in March 2015, to enhance the nuclear disaster management system.

Table 1 shows the revision of contents of Basic Act on Disaster Control Measures. Especially, it has been said that matters of “Evacuation Place and Refuge Instruction” are important due to preventing heavy damage by experience of the Great East Japan Earthquake. Soft measurements such as the collection and transmission of information have been becoming much more important because the disaster prevention measure that is only hard infrastructures have a limit.

Table 1. Revised contents of Basic Act on Disaster Control Measures [5)]

No	Article that revised and added	Year of promulgation and enforcement
1	Standard of the designated emergency shelter*	September, 2013
2	Standards of designated Shelter**	September, 2013
3	Create list of People need Assistances***	June, 2013
4	Collecting and transmitting information	June, 2012

*) Facilities for inhabitants to plan personal security depending on disaster classification temporarily
**) Facilities for inhabitants to have visited while the risk of the disaster disappears or for inhabitants can’t come back to house by disaster to have visited temporarily
***) People need Assistances is Elderly person, The handicapped and Babies

3. Questionnaire survey about Recognition for Disaster Prevention Information

We carried out a questionnaire survey about disaster prevention focused on “Shelter” for 224 students (Undergraduate Student to Doctor Course Student) who belong to the Department of Architecture, Faculty of Environmental Engineering, The University of Kitakyushu.

As the results of the survey, Figure 5 (left) shows 58% of students is “Boarders”. Also, Figure 5(right) shows 35% of the total students understand where “Shelter or Evacuation Place” is when the disaster happens. Therefore, The Disaster Prevention Information is not recognized well by the student.

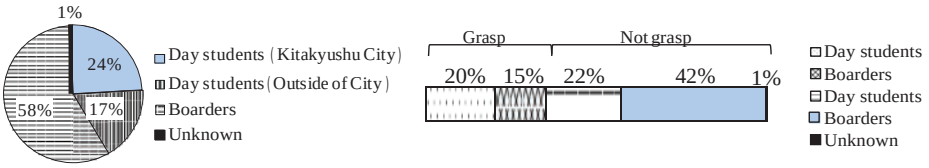

Fig 5. (L) Breakdown of Students, (R) Breakdown of answer about “Shelter or Evacuation Place”

*) Day students: Student goes to school from parents' house
**) Boarders: Students goes to school from a dormitory or lodging because parents' house is so far

4. Present Conditions of Information Disclosure to Residents for disaster

In this chapter, we add “Ordinance-designated city of Kyushu jurisdiction”. Fukuoka and Kumamoto, which have the same scale with Kitakyushu, are added to be the study area (Fig 6). Also, we analyzed present situation about information disclosure of disaster to residents in the study areas.

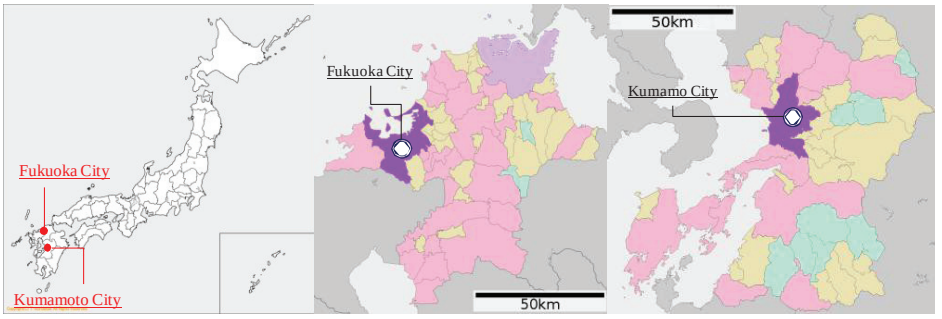

Fig 6. Location of Fukuoka City and Kumamoto City

4-1. Characteristic of Disclosed Disaster Prevention Data

In municipalities of the study areas (Fig 7), “Disaster Prevention Data” including “Regional Disaster Prevention Plans”, “Disaster Prevention Homepages”, and “Disaster Prevention Information Map” all can be opened online by the residents.

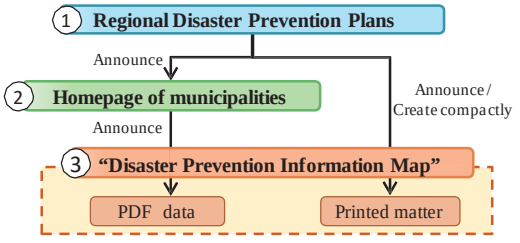

Fig 7. Characteristic of disclosed Disaster Prevention Data[6)]

“Regional Disaster Prevention Plans” was created as a guidance to plan regional policy of disaster prevention. In “Homepage of municipalities”, the information including “Regional Disaster Prevention Plans”, “ Disaster

Prevention Information Map" and Shelter, and "Disaster Prevention Information Map" was created in order to visualize "Regional Disaster Prevention Plans" compactly and distributed as printed matter for residents, which is a map to show the shelter and disaster prediction points of place in the areas (Fig 8).

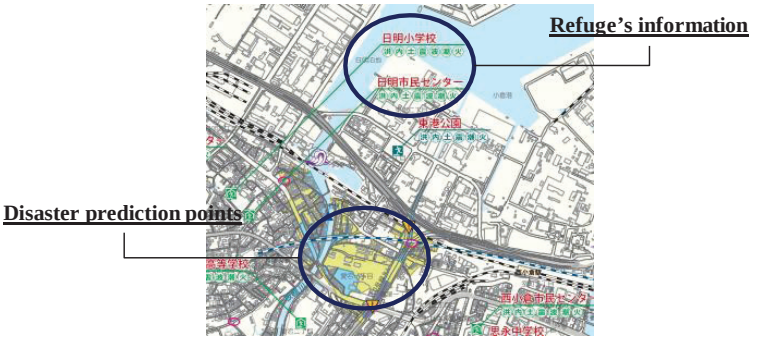

Fig 8. An example of "Disaster Prevention Information Map" [6)]

4-2. Access to Disaster Prevention Information Map

In this session, we compared how to obtain "Disaster Prevention Information Map" based on municipalities' homepages. Fig 9 shows the example of notation due to access to "Disaster Prevention Information Map". These figures show the homepage screens of each place (Fukuoka and Miyako). Fukuoka homepage shows the banner of disaster prevention on the top of the front page. Miyako uses both map and letters as guide display of "Disaster Prevention Information Map". From these two cases, we found two things; firstly, although accessing to information immediately by homepage screen is necessary to obtain information quickly in an emergency, the expression method, such as position and color of the banner on homepage screen, are different from each other. Secondly, there are some ways to show the notation on the home page screen, i.e.: using the map or letter to display the access "Disaster Prevention Information Map".

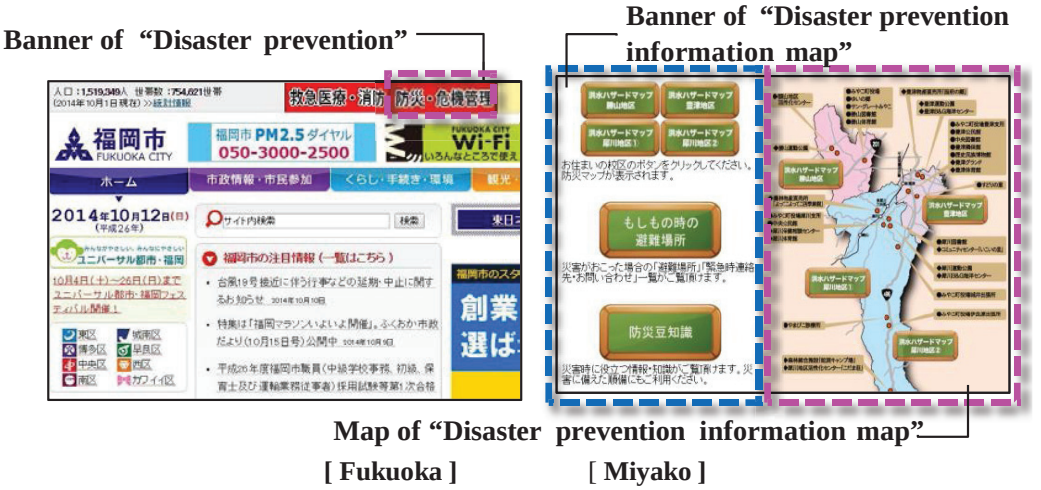

Fig 9. Banner or Map on homepage screen (Fukuoka and Miyako) [6)]

4-3. Shelter's Notation

Next, we focused on "Shelter's Notation" which shown in "Disaster Prevention Information Map" and classified 12 municipalities in 2 groups (A and B) based on "Shelter's Notation" (Table 2). Municipalities in A group use one

expression for “Shelter’s Notation”, and municipalities in B group use two or more expressions for “Shelter’s Notation”. Therefore, due to the municipality that use different “Shelter’s Notation”, residents will be confusing to judge their activities during the disaster prevention.

Table 2. Shelter’s Notation [6)]

Local government	Disaster Prevention Information Map Noation of Shelter	Classification reason	Growp
Ashiya-Machi	Shelter(public facilities), Shelter(community center)	Priority levels	B
Mizumaki-Machi	Shelter	—	A
Nakama City	The first refuge	—	A
Nogata City	Shelter	—	A
Fukuchi-Machi	Shelter for evacuating voluntarily, Shelter of evacuation recommendation or evacuation instruction	Priority levels	B
Kawara-Machi	Shelter at the time of Disaster	—	A
Miyako-Machi	The first refuge, The second refuge	Priority levels	B
Kanda-Machi	Shelter, Shelter(Shelter for evacuating voluntarily)	Priority levels	B
Yukuhashi City	The first refuge, The second refuge	Priority levels	B
Kitakyushu City	Planned Shelter	—	A
Fukuoka City	Evacuation shelter, Evacuation center	Capacity	B
Kumamoto City	Evacuation place	—	A

4-4. Hearing Survey about Shelter Information

This session shows Kitakyushu’s case of shelter application. We carried out a hearing survey to the city of Kitakyushu about the shelter information and its management system. Japanese local governments have opened the application system to accept the private facilities, such as private schools as a shelter beside the public facilities. After the application, the local government will be announced to the citizens. Fig 10 shows shelter application system and information announcement system in Kitakyushu.

Firstly, each of Ward offices gives the intention to shelter facilities’ candidate. Secondly, Shelter facilities’ candidate reports the provided places to ward offices. Thirdly, ward office reports new shelter’s application to

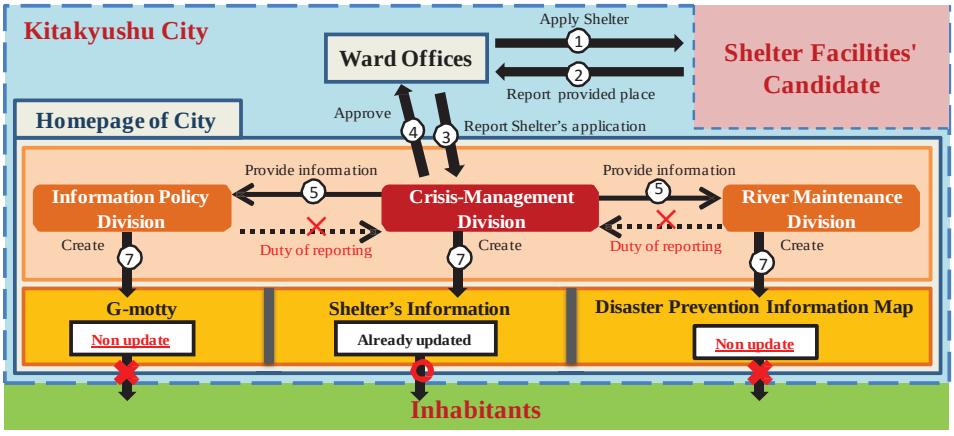

Fig 10. Shelter application system and information announcement system in Kitakyushu

*) Information Policy Division, Crisis Management Division and River maintenance Division are department of Kitakyushu city.
**) “G-mmoty”, “Shelter’s Information” and “Disaster Prevention Information Map” shown Shelter Information of Kitakyushu City
***) “G-mmoty” is GIS of type unified municipalities. This system have been started based on second revision of “Basic Act on Disaster Control Measures” since October, 2013.

"Crisis Management Division". Fourthly, "Crisis Management Division" provides new shelter's information to two departments; "Information Policy Division" and "River Maintenance Division". Lastly, three departments such as "Information Policy Division" update each information and announce it to the residents.

In June 2014, four facilities, including Kyushu Kyoritsu University, which is a private school, were recognized as a shelter. At the end of August 2014, we accessed the homepage of Kitakyushu and found "G-motty" or "Disaster Prevention Information Map" was not updated. Then, we heard from the "Crisis Management Division" and got answers that although they followed the division rules which designed by the government to inform the other department about the information about shelters, they have no duty to request the other department to update. "Crisis Management Division" started in 2012 is the organization directly led by the mayor to carry out duties specialized in disaster regulation of Kitakyushu. We were very surprised for the system that is a lack of the responsibility for the crisis control. (After one year late, Information update was carried out in June 2015.).

5. Improvement of Disaster Prevention data by Using Urban Planning Information

5-1. Association between Disaster Prevention Map and Geographic Information System

In Flood Prevention Law provisions 2001, the government needs to specify the "Flood expected area" in response to flood damage that frequently occurs due to the heavy rains and inform to the heads of the relevant municipality. Also, each of mayors of the municipality that have the river basin correspond to "Flood expected area" is demanded to create "Flood Hazard Map" (Disaster Prevention Information Map) which include information of "Flood expected area" and inform it to the residents by printed matter or other measurement.

We suggest the better way to make this process smoothly by creating the Disaster Prevention Information Map based on the urban planning information, such as Geographic Information System (GIS). There are two reasons for this suggestion: firstly, existing disaster prevention information map is created by marking the points on the background map of the roads and streets. On the other hands, the urban planning information system can be created by using position coordinate of disaster prevention information (public coordinates or latitude and longitude) on disaster prevention information map. This disaster prevention information map can be created from many fields. The data that made in the urban planning information system also can use the function like overlay, extraction and combination to support the planning for disaster prevention. Secondly, in the second Amendment of Disaster Countermeasures Basic Act (June 2012 Act Article 51) stated that with the development and dissemination of IT technology using urban planning information system was required for the collection and transmission of information on disaster. Fig 11 shows the map that created by GIS data. The data, created by the urban planning information system, is seamless data that do not limit to the background map. It is possible to create a map with some purpose by extracting and overlaying the boundary data of interest.

The DATA created by the city planning information system can be as output of the various types and models in

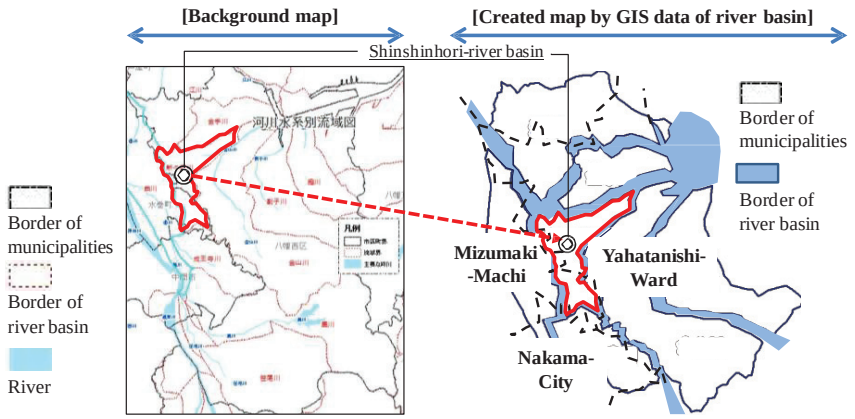

Fig 11. Created map by GIS data of river basin instead of municipalities

addition to the printed matter. The DATA can be converted to all formatted matter and easy to print in the PDF format.

5-2. Result of Analysis based on using urban planning information system

We unified the shelter notation of the study areas based on the problems found in the current situation analysis. In this study, we constructed a system of disaster prevention in GIS and analyzed it to the "evacuation difficult area", “the population of the evacuation difficult area", and "new shelter candidate" from the current shelter data.

5-2-1. Construction Method

(1) The Creation of "Possible Evacuation Area."

The range of “Possible Evacuation Area” was decided in a radius of 500m from “Planned Shelter” based on “Facilities maintenance guidance of Miyagi Prefecture”. [7]

(2)The Creation of “Evacuation Difficult Area.”

We put “Living Area” on “Possible Evacuation Area” by Overlay.

(3) The Calculation of Residents’ Population of “Evacuation Difficult Area.”

We calculated the population in the “Evacuation Difficult Area” by overlaying difficult evacuation area and per 5-year-old population by the national census.

5-2-2. Result of Calculation

Among the Evacuation difficult area, the selected areas where there are more than 100 people were 160 locations. Table 3 showed 15 places where the population is more than 2500 people as “the Evacuation difficult area”. Figure 12 shows an example of new possible shelters in Yukuhashi City. Also from the Table 3, we can find that in six Wards of Kitakyushu, there may be no public facilities as the candidate of the new shelter.

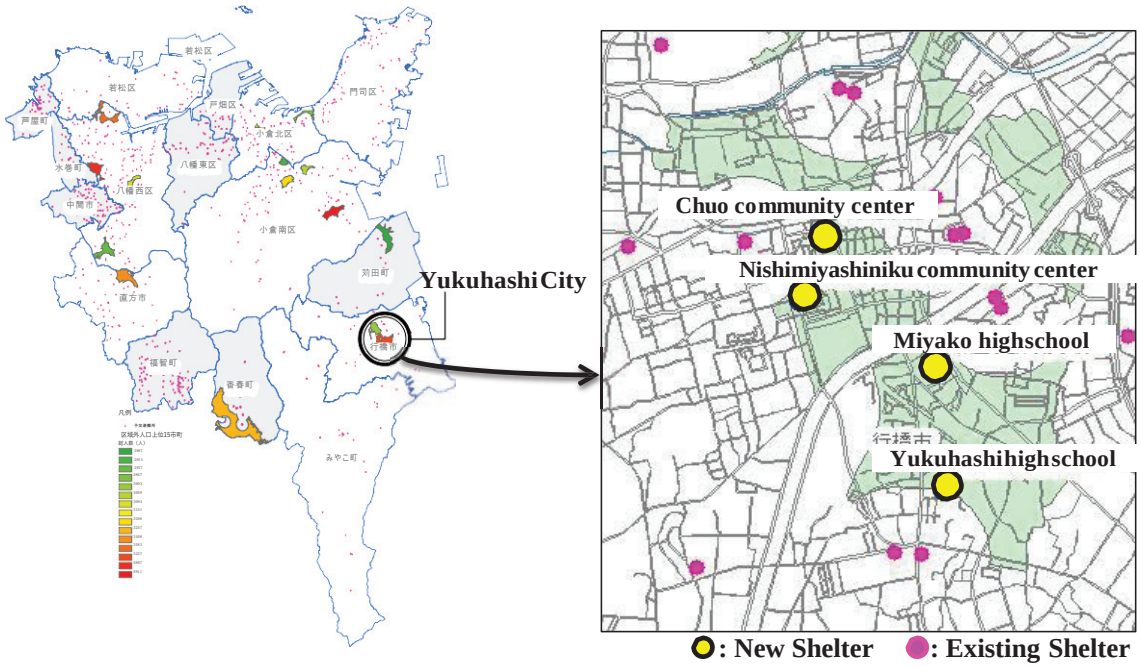

Fig 12. An example of new shelters of area picked automatically (ID30 and 33)

Table 3. Data of the existing shelter and the new shelter in each of 15 places

ID	Municipality	Adress	Square measure (m2)	Total population	Population (0~14 ages)	Population (more than 65 ages)	New Shelter
2	Kanda-Machi	Saiwaimachi, Kanda-machi Miyako-County, Fukuoka	1221370	2687	440	497	Matsuyama community center Matsubara community center
30	Yukuhashi City	Izumichuo, Yukuhashi City, Fukuoka	1551164	5257	685	1245	Miyako high school Yukuhashi high school
33	Yukuhashi City	Chuo, Yukuhashi City, Fukuoka	607243	3003	346	748	Chuo community center Nishimiyashiniku community center
59	Nogata City	Ganda, Nogata City, Fukuoka	1300325	3408	526	807	Jofuku Temple Jofuku-ji Kindergarten
163	Kokuraminami-Ward	Shigezumi, Kokuraminami-Ward Kitakyushu City, Fukuoka	314399	2815	377	728	Elder rest house
168	Kokuraminami-Ward	Kuzuhara, Kokuraminami-Ward Kitakyushu City, Fukuoka	390642	3009	383	940	Not applicable
176	Kokuraminami-Ward	Shimoishida, Kokuraminami-Ward Kitakyushu City, Fukuoka	623493	3206	459	689	Not applicable
195	Kokuraminami-Ward	Shimonuki, Kokuraminami-Ward Kitakyushu City, Fukuoka	927374	5911	817	1457	Jodo Temple Jodo-ji Kindergarten
217	Kokurakita-Ward	Kamitomino, Kokurakita-Ward Kitakyushu City, Fukuoka	411845	2867	293	882	Anraku Temple
230	Kokurakita-Ward	Kanada, Kokurakita-Ward Kitakyushu-City, Fukuoka	219931	3151	454	583	Not applicable
244	Yahatanishi-Ward	Ohiraki, Yahatanishi-Ward Kitakyushu-City, Fukuoka	1070451	3583	576	625	Not applicable
267	Yahatanishi-Ward	Shojusan, Yahatanishi-Ward Kitakyushu-City Fukuoka	842978	5897	827	1309	Not applicable
271	Yahatanishi-Ward	Uenoharu, Yahatanishi Ward Kitakyushu-City, Fukuoka	621536	3094	412	824	Not applicable
284	Yahatanishi-Ward	Koyanose, Yahatanishi-Ward Kitakyushu-City, Fukuoka	1024718	2817	333	840	Kusubashichuo community center
386	Kawara-Machi	Nakatsubaru, Kawara-machi Tagawa-County, Fukuoka	5787048	3257	403	980	Fudokyouiku community center Tinzeinishikyouiku community center

6. Summary

In this study, we focused on the action of “Self-assistance” and shelter on “Storm or Flood Damage” in a wider area. Firstly, we conducted a survey of the disaster prevention information that is released by the administrative local government and found that the recognition for “Disaster Prevention Information” was not informative enough. The presentations of disaster prevention information maps on the home page of the studied cities do not have unity, and there are some unclear parts of the disaster information. There is still room to improve the advertisement activities for the residents.

Residents have difficulty to recognize the notation of the shelter in the information map because of different categorization due to the reason of the administrative side, especially for the residents near the boundary between the cities. We also found the update information cannot be delivered quickly and exactly. It is urgent to make shelter information of each municipality have in unity from the viewpoint of wider area disaster prevention. The homepage of the disaster prevention information should be improved.

In this paper, we tried to construct a scheme to make the Disaster Prevention Information Map based on the urban planning information. Geographic Information System (GIS) can be used in many cases in the disaster prevention information system.

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